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Vedvarende energi, Smart Grids og Japan

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Vedvarende energi, Smart Grids og Japan

Professor and head of center
Jacob Østergaard

Agenda

1. Baggrund
2. Center for El og Energi
3. Vedvarende energi og smart grids i Danmark
4. Vedvarende energi og smart grids i Japan

Baggrund

- Disclaimer vedr. Japan og økonomi

- Japan-samarbejde i 90'erne vedr superledende kabler
- Besøgt Japan december 2013 mhp. Dansk-Japansk energisamarbejde
- Besøg af Japans ambassadør m.fl. i vores labs PowerLabDK
- Besøg om 14 dage af børsnoteret Japansk firma som vi teste deres teknologi i DK

History of DTU – a short introduction

Established | **Present Campus** | **Mergers & Autonomy**

1829 1857 1903 1970 1974 1994 1995 2001 2007 2008

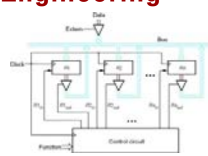
Den Polytekniske Læreanstalt (1829, 1857)

HC Ørsted

Chemistry

Mech. Eng.

Electrical Engineering (1903)



Civil Engineering

IT (1970)

New campus inaugurated (1974)

Merger with DIA (1994)

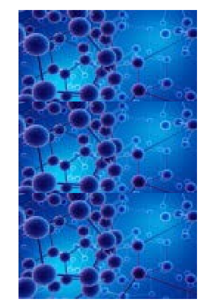
Renamed DTU (1995)

DTU-Act & autonomy (2001)

Merger with: (2007)

- Risø National Laboratory
- Danish National Space Center
- Danish Institute for Fisheries Research
- The Danish Institute for Food and Veterinary Research
- Danish Transport Research Institute

Life-science & Bioengineering (2008)



DTU Mission

DTU will develop and create value using the natural sciences and the technical sciences to benefit society

Education

Innovation

Public Sector Services

Research

DTU

DTU Lyngby Campus

DTU Risø Campus

Scion DTU

DTU Vet/Food/Aqua

DTU Høvsøre/Østerild

DTU DANA

Key figures	
Students	7.600
Ph.d.'s	1.300
Staff	5.000
Budget	605 MEuro

Center for Electric Power and Energy (CEE)
Department of Electrical Engineering

- Established 15 August 2012 as a merger of existing units (Lyngby+Risø)
  - One of the strongest university centers in Europe with >90 employees
  - A single, clear interface to the field at DTU for external collaboration
- International evaluated research; Discipline oriented -> proof-of-concept
- Bachelor and master programs
  - Electrical Engineering
  - Wind Energy
  - Sustainable Energy
- Main competences
  - Electric Power Engineering
  - Automation and control
  - Information and Communication Technology
- Strategic partnerships

Smart Grids

Use of ICT in the Electric Power System to Efficiently Integrate Large Share of Renewable Energy

Denmark is a European Smart Grid Hub

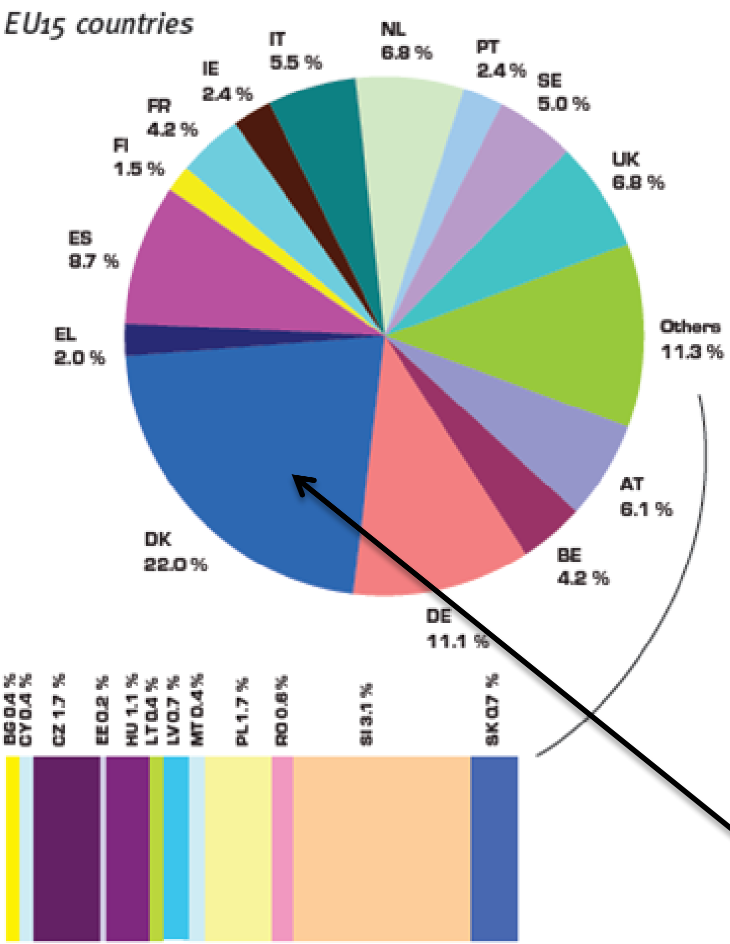
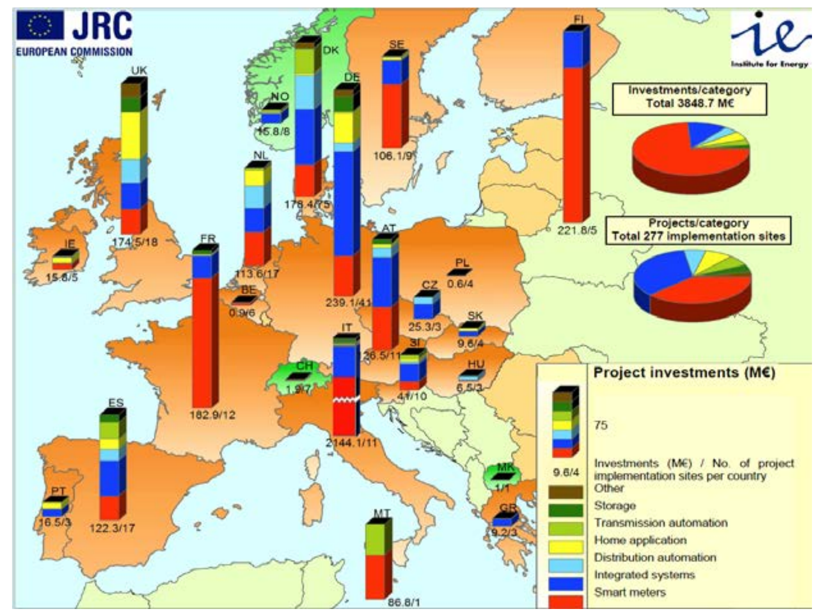


Figure 1. Distribution of projects between EU15 and EU12 Countries



22% of EU smart grid projects takes place in Denmark

Strong National and International Collaboration

Selected Partners

- ***Academic partners:***

ETH Zürich (CH)
TU Delft – Delft University of Technology (NL)
Berkeley – University of California (US)
University of Delaware (US)
Tsinghua University (CN)
Aalborg Universitet (DK)
The Hong Kong Polytechnic University 香港理工大學 (HK)

NORDIC FIVE TECH
DTU (DK)
NTNU – Norwegian University of Science and Technology (NO)
Aalto University School of Science and Technology (FI)
Chalmers (SE)
KTH (SE)

+ many more

- ***Commercial and industrial partners:***

Energinet.dk (DK)
DONG energy (DK)
SIEMENS – Siemens Wind Power (DK)
elia – Powering a world in progress (BE)
ØSTKRAFT – energi til gode oplevelser (DK)
nationalgrid (UK)
IBM (CH)
Vestas (DK)
Pacific Northwest National Laboratory (US)
Danfoss (DK)
seas-nve (DK)
SIEMENS (DE)
VESTFROST SOLUTIONS (DK)
nkt cables (DK)

+ many SME's

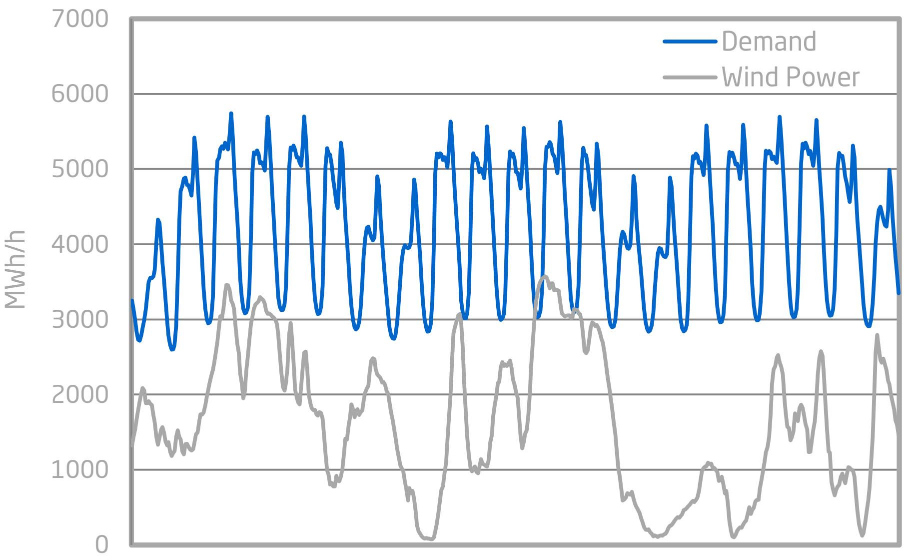
- ***Networks:***

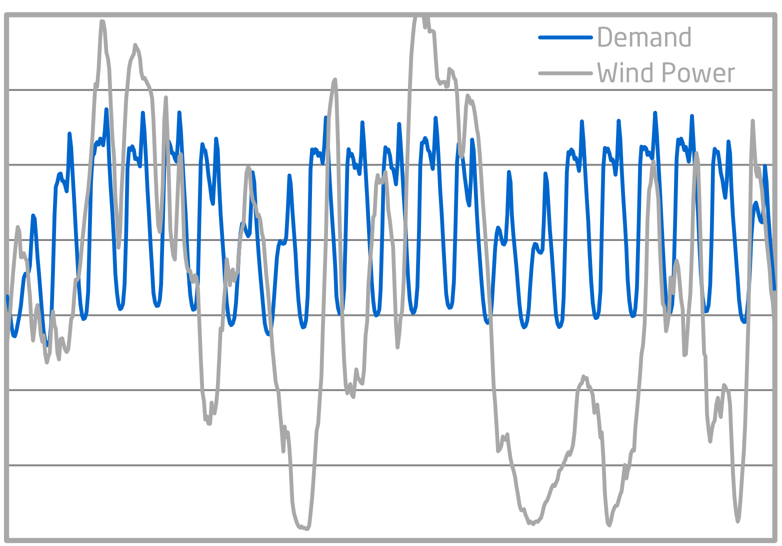
SMARTGRIDS (EU)
EERA – European Energy Research Alliance (EU)
iea Energy Technology Network – ISGAN – International smart grid action network (Global)
IEEE PES – Power & Energy Society (Global)

Research Challenges addressed by CEE

2012
25% wind power

2020
50% wind power

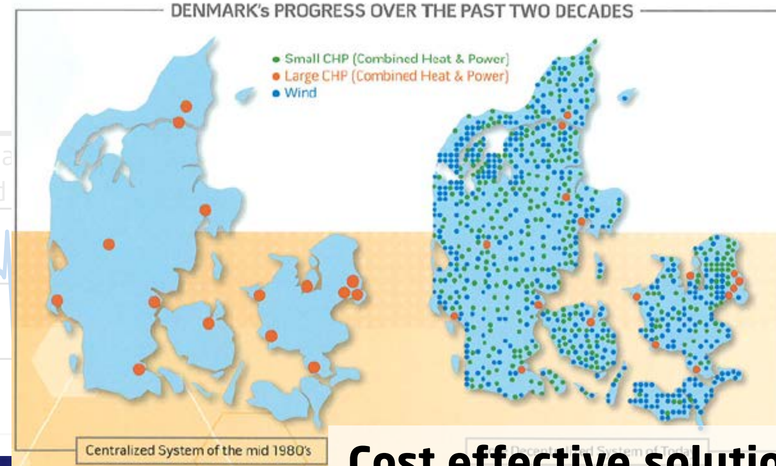




Research Challenges addressed by CEE

Balancing:

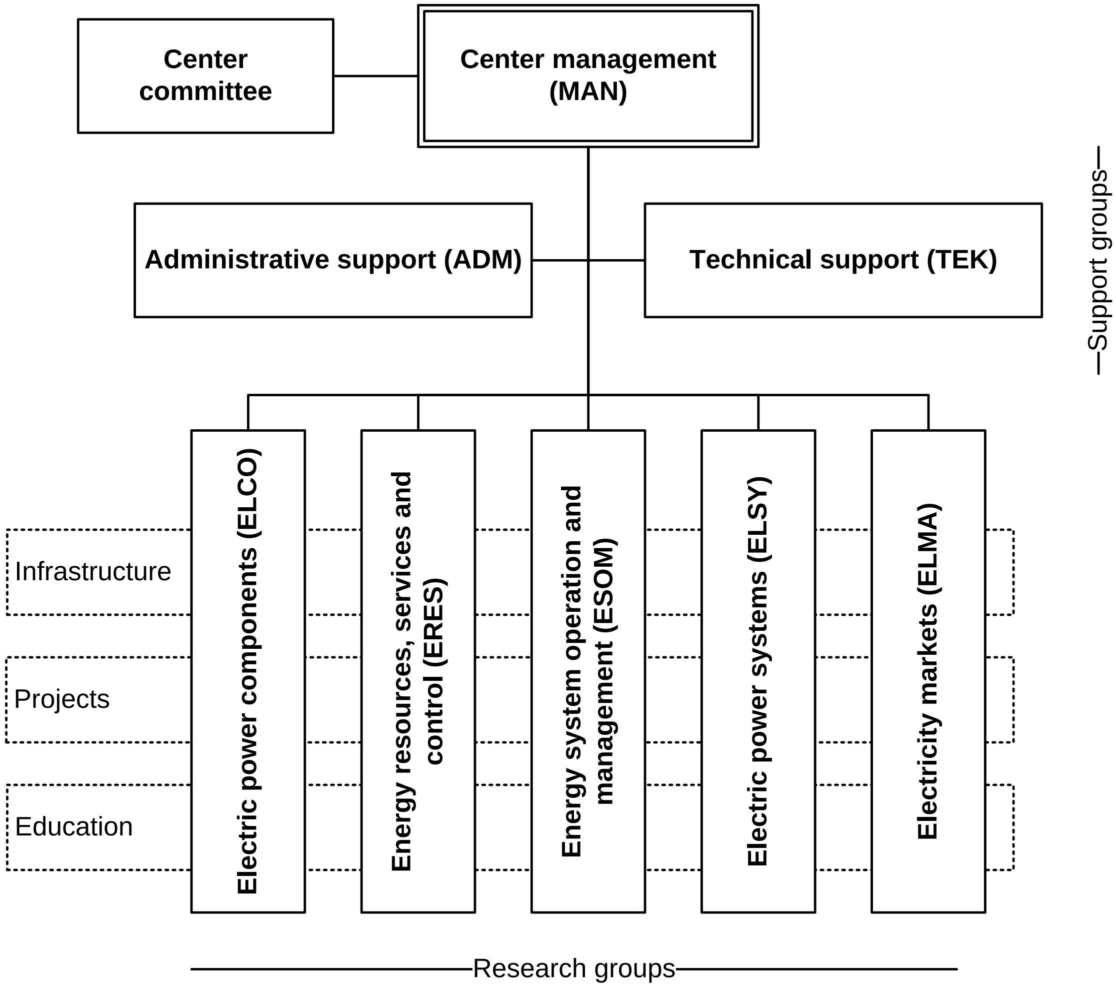
Changed Generation Landscape:



Stability and Reliability:

Cost effective solutions:

Center for Electric Power and Energy
Organisation



Head of Center

Jacob Østergaard

Deputy Head of Center

Joachim Holbøll

ADM
Solveig Lind Bouquin

TEK
Per Munch Jakobsen

ELCO
Joachim Holbøll

ELSY
Arne Hejde Nielsen

ELMA
Jacob Østergaard (interim)

ERES
Chresten Træholt

ESOM
Henrik Bindner

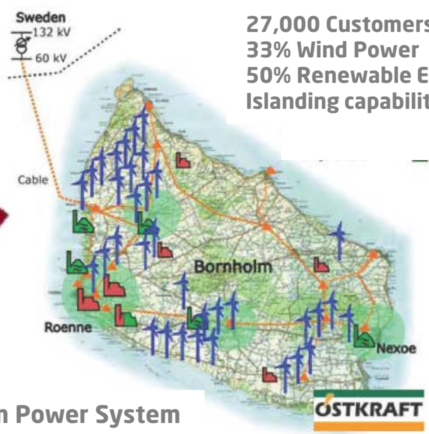
PowerLabDK combines experimental facilities

Flexible multi-purpose laboratories

Lyngby &
Ballerup Campus

Large-scale test system

Risø Campus



27,000 Customers
33% Wind Power
50% Renewable Energy
Islanding capability

Full-scale Realistic Power System

Bornholm Power System

Stakeholders:

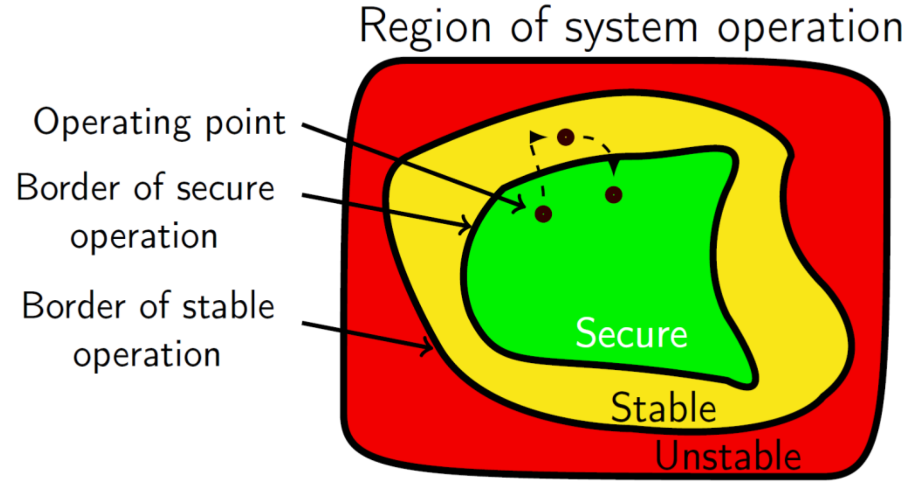
ABB, nkt cables, dansk energi, SIEMENS, DONG energy, VATTENFALL, ENERGINET/DK, Vestas, IBM

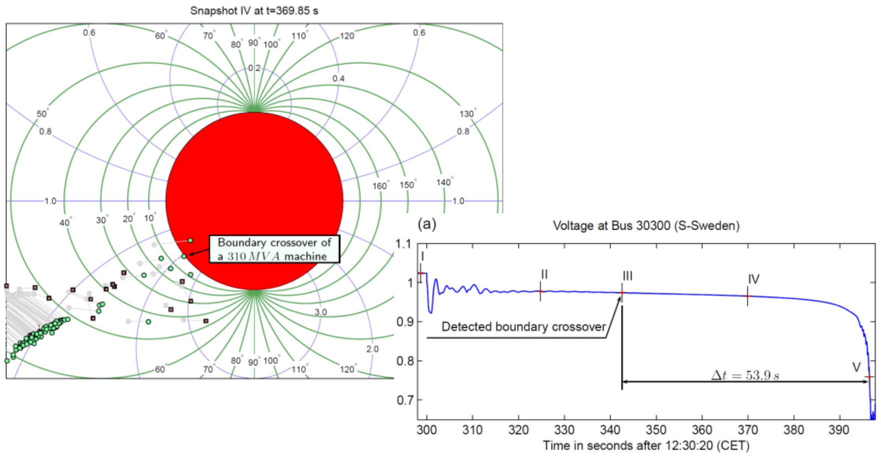
Supported by:

GREEN LABS DK, EUDP

Investment:
18 million Euro

Stability and security assessment in real time (ms-range)





Conventional approaches

- Historically off-line analysis
- Assessment times of 5 – 15 minutes
- Insufficient for systems with high share of stochastic energy sources

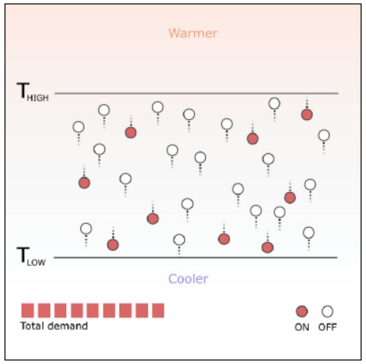
Developed approach

- Real-time monitoring of operating condition
- PMU's as enabling technology
- Analytical approach
- Assessment time (7917 nodes, 1325 gens, ≈2.5 ms)
- Early warning (2003 SW-DK blackout -> Δt ≈80 s)
- Remedial actions can easily be calculated (wide area control)

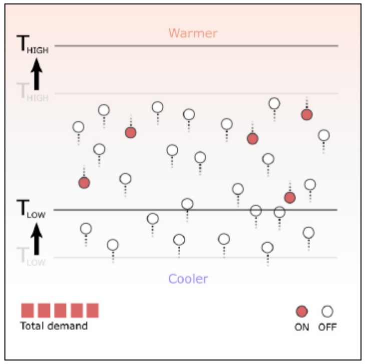
Refs: *International Journal on Power and Energy System*, 2012
Patent No. 111681113.6 – 2207, 2011
Patent No. EP11195960.7, 2011

System Reserves Provided by Frequency Responsive Electricity Demand

Grid frequency at 50Hz

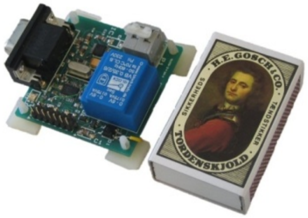


Grid frequency **falls below** 50Hz



$$T_{high} = T_{high}^{normal} - kf(f - f_0)$$

$$T_{low} = T_{low}^{normal} - kf(f - f_0)$$

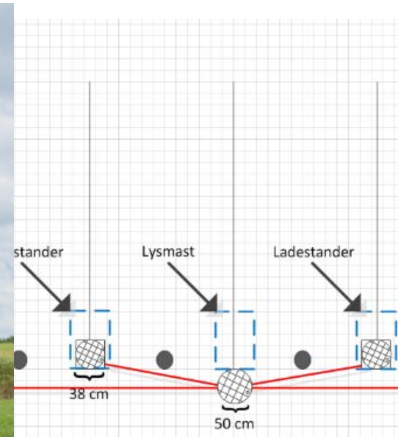


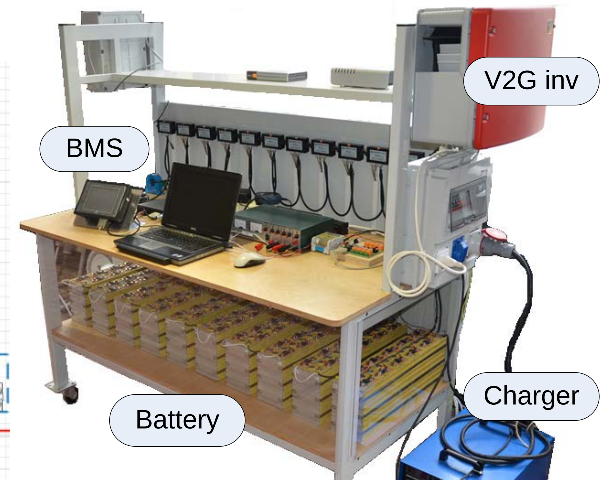
Field test at Bornholm

Field test w. 200 residential, commercial and industrial demand units

Refs: *IEEE Transactions on Power Systems*, August 2011.
IET Generation Transmission and Distribution, August 2009.

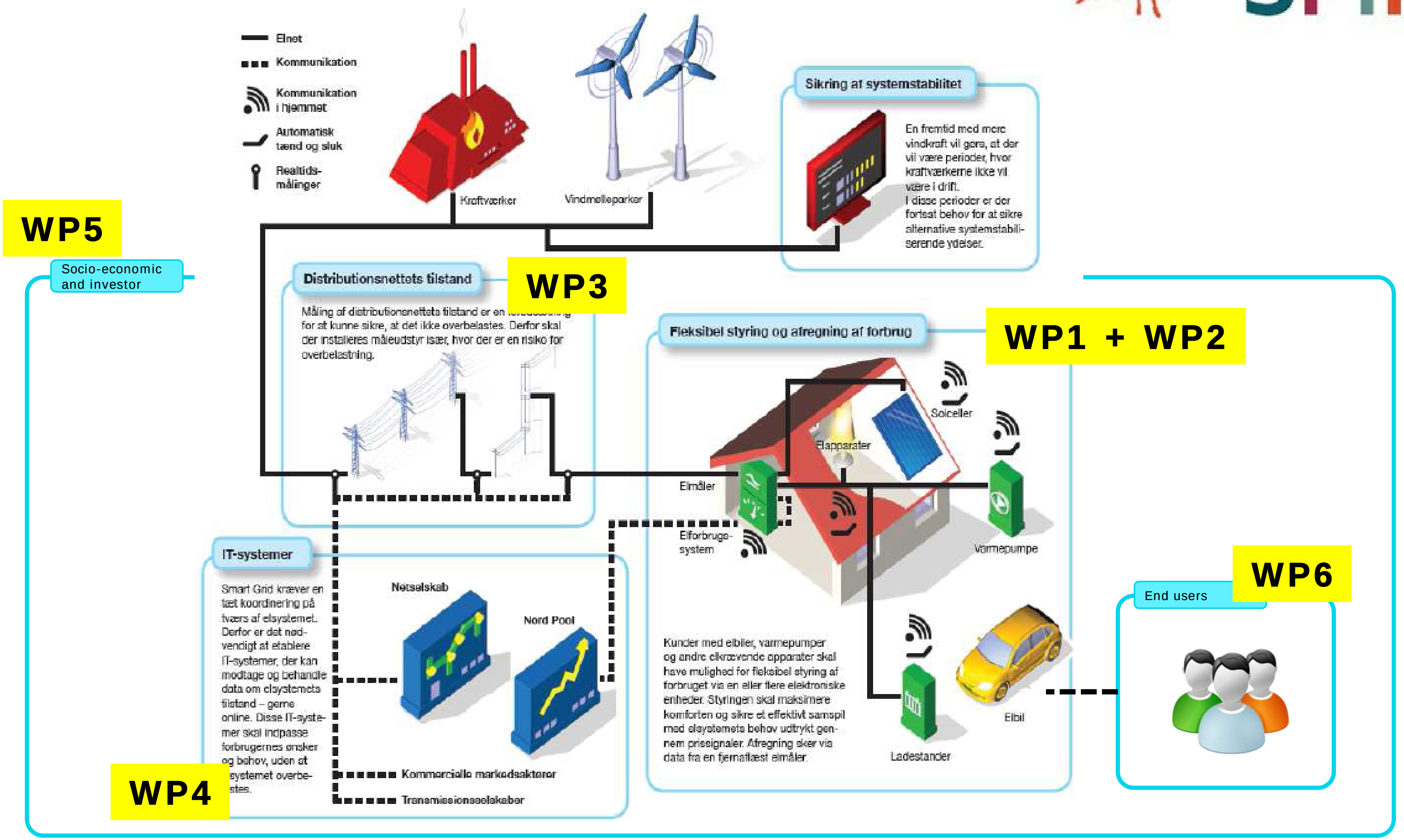
Intelligent System Integration of Electric Vehicle





iPower – strategic program for research and innovation

Budget: 120 million DKK

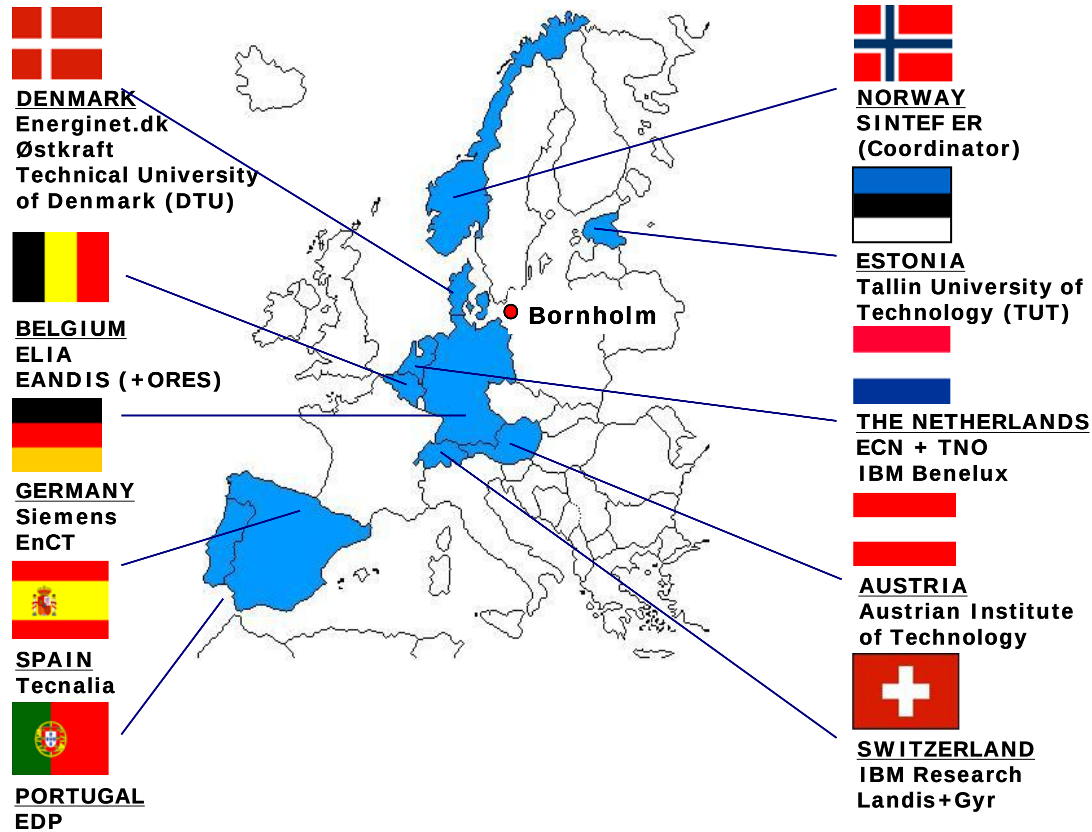


Source: Based on draft drawing by Danish Energy Association.

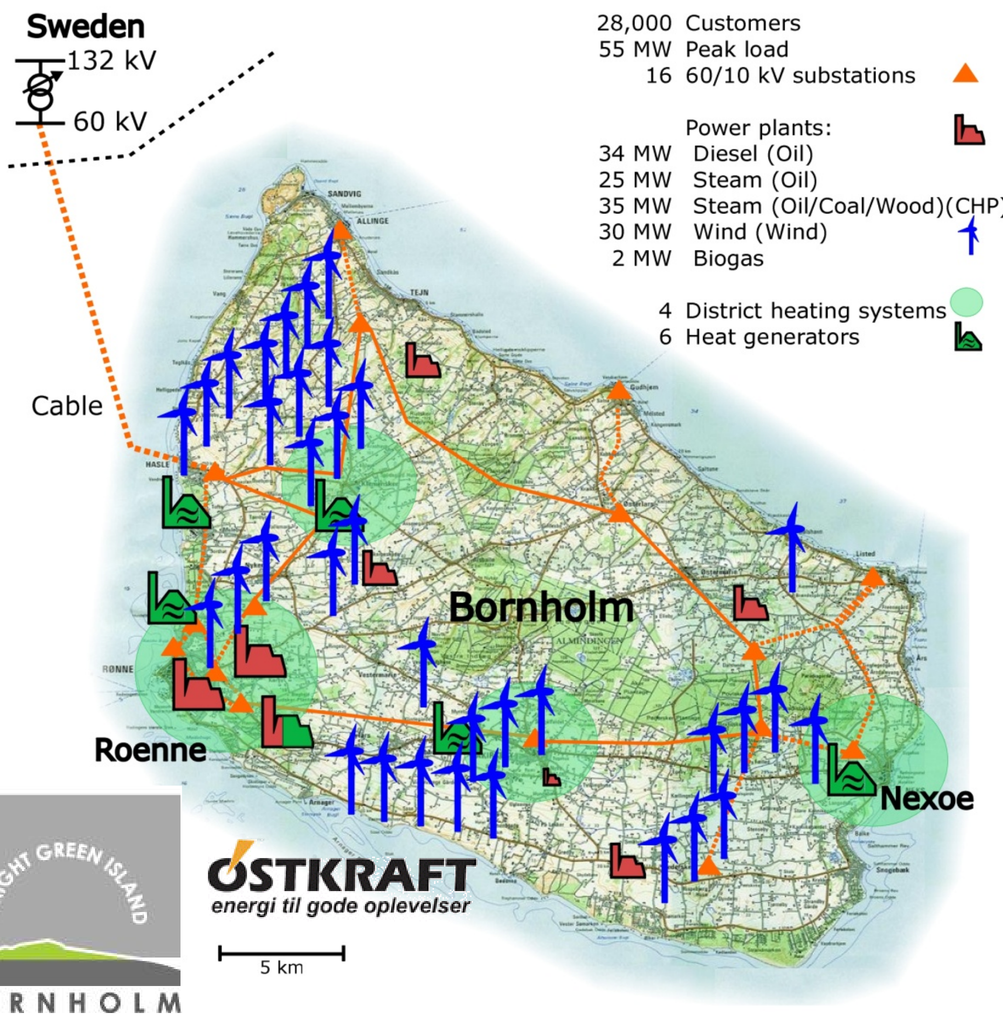
EcoGrid EU

Large-scale demonstration of the future intelligent distribution system

- EU FP7 ENERGY
- 2011-14
- Budget: 21 million Euro
- Integrated research and demonstration
- ~2,000 active customers
- EU fast-track to Smart Grids



Bornholm Full-Scale Laboratory – 1% of DK
33% Wind Power Penetration; 28,000 Customers



Energy strategy
Political & public drive

BORNHOLM.DK
BRIGHT GREEN ISLAND

Energy resources:

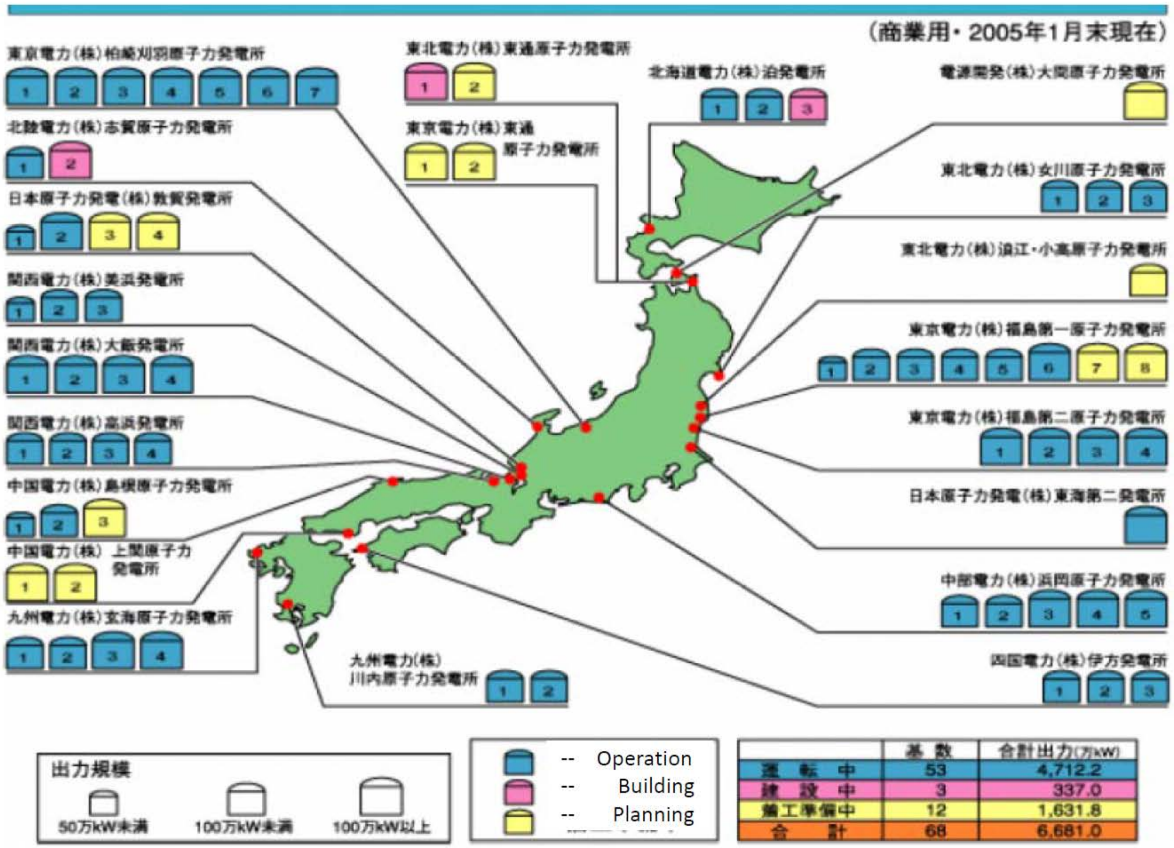
- *Customers*
- *Wind power*
- *Biogas plant*
- *Combined heat and power*
- *District heating*
- *Solar power plants*
- *eMobility*

Features:

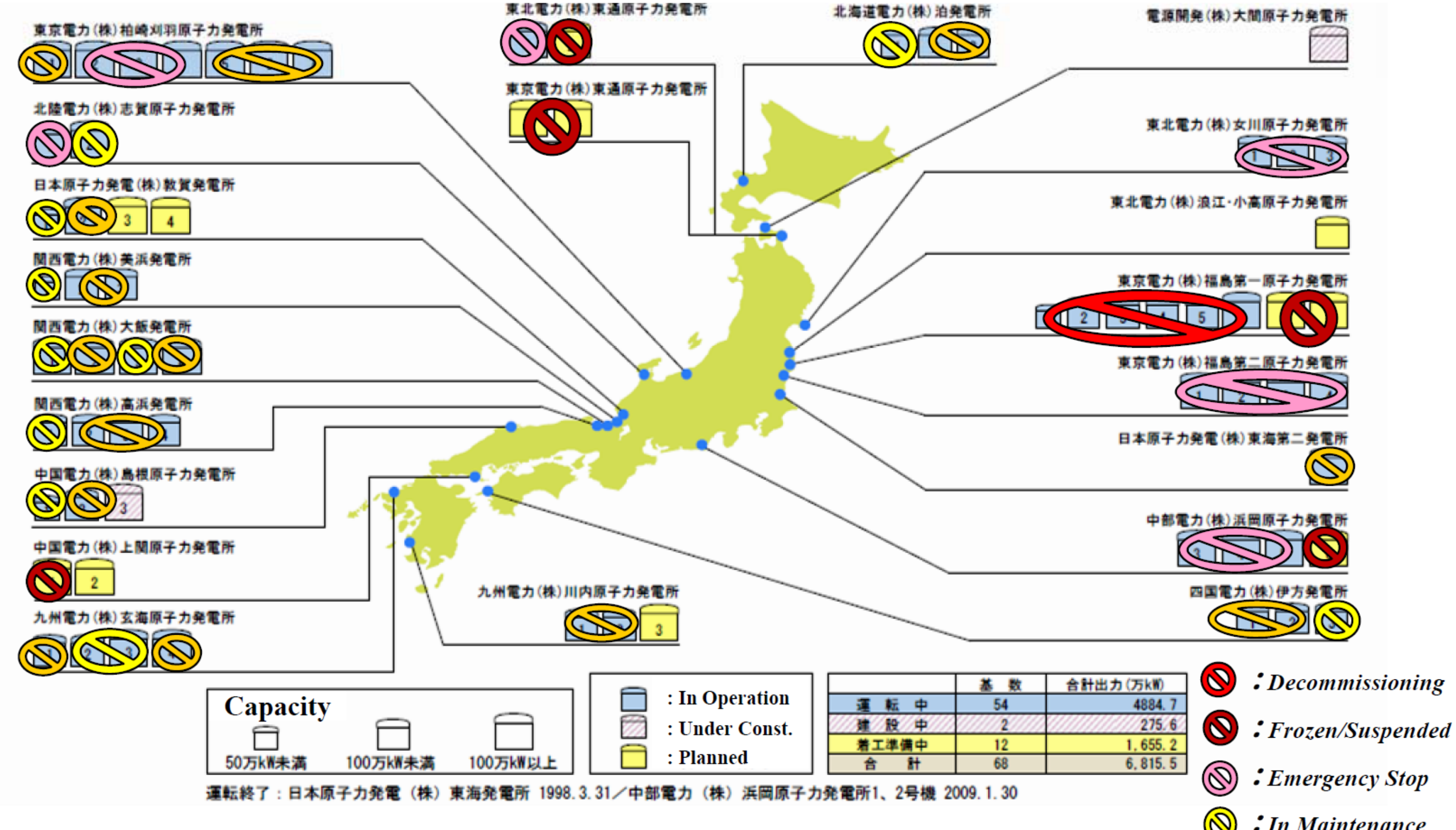
- *Nord Pool market (DK2)*
- *Islanding capability*


After the Disaster
on March 11, 2011
10

Nuclear Power Generation Plant in Japan before Earthquake 2011



Current Situation of Nuclear Plants After Disaster in Japan



	基　数	合計出力(万kW)
運　転　中	54	4884.7
建　設　中	2	275.6
着工準備中	12	1,655.2
合　　計	68	6,815.5

運転終了：日本原子力発電（株）東海発電所 1998.3.31／中部電力（株）浜岡原子力発電所1、2号機 2009.1.30

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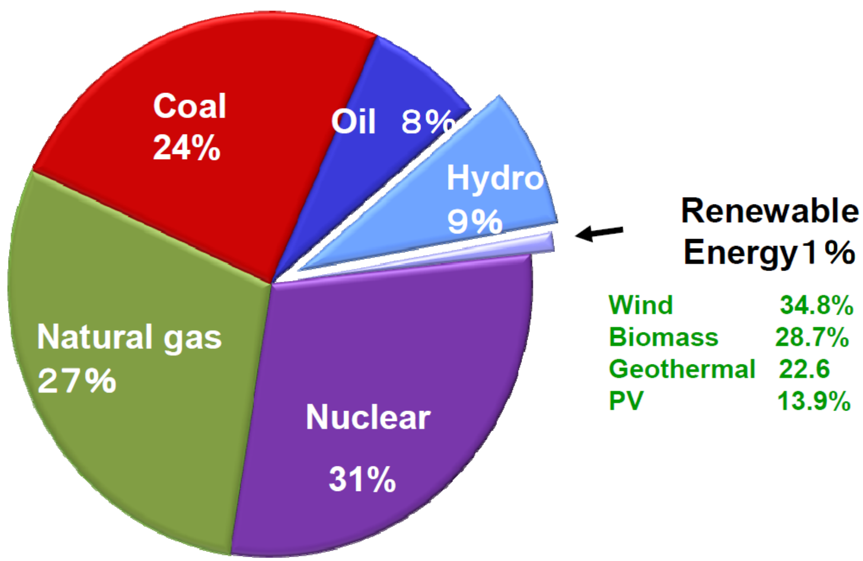
RENEWABLE ENERGY IN POWER GENERATION MIX 2009

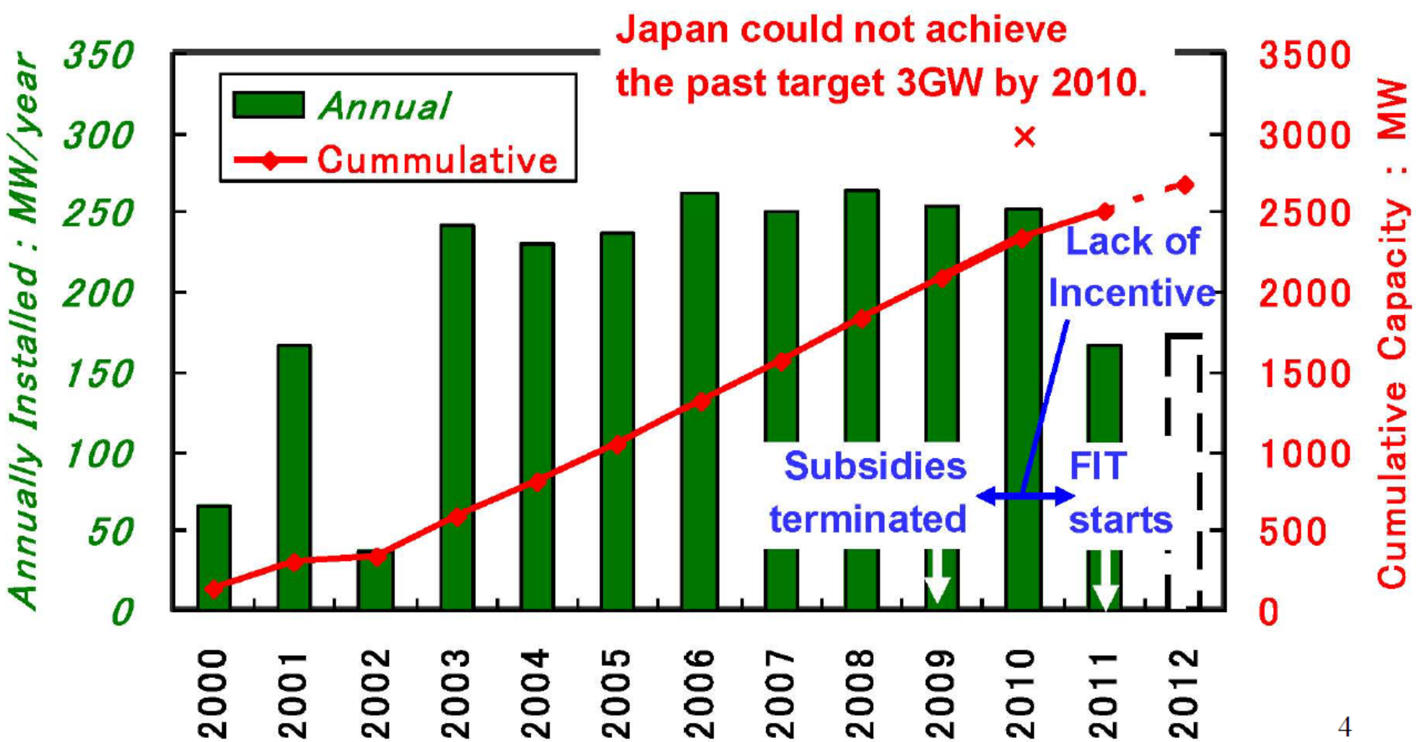


Source: METI

Wind Power Generation in Japan

<u>Latest wind Power Statistics in Japan (at the end of 2011)</u>

- Total installed wind generation : 2,501MW, 1,832 units
- New wind generation installed : 167 MW / year
- Total electric output from wind : 4246 GWh / year
- Wind generation share of national electric demand : 0.5 %



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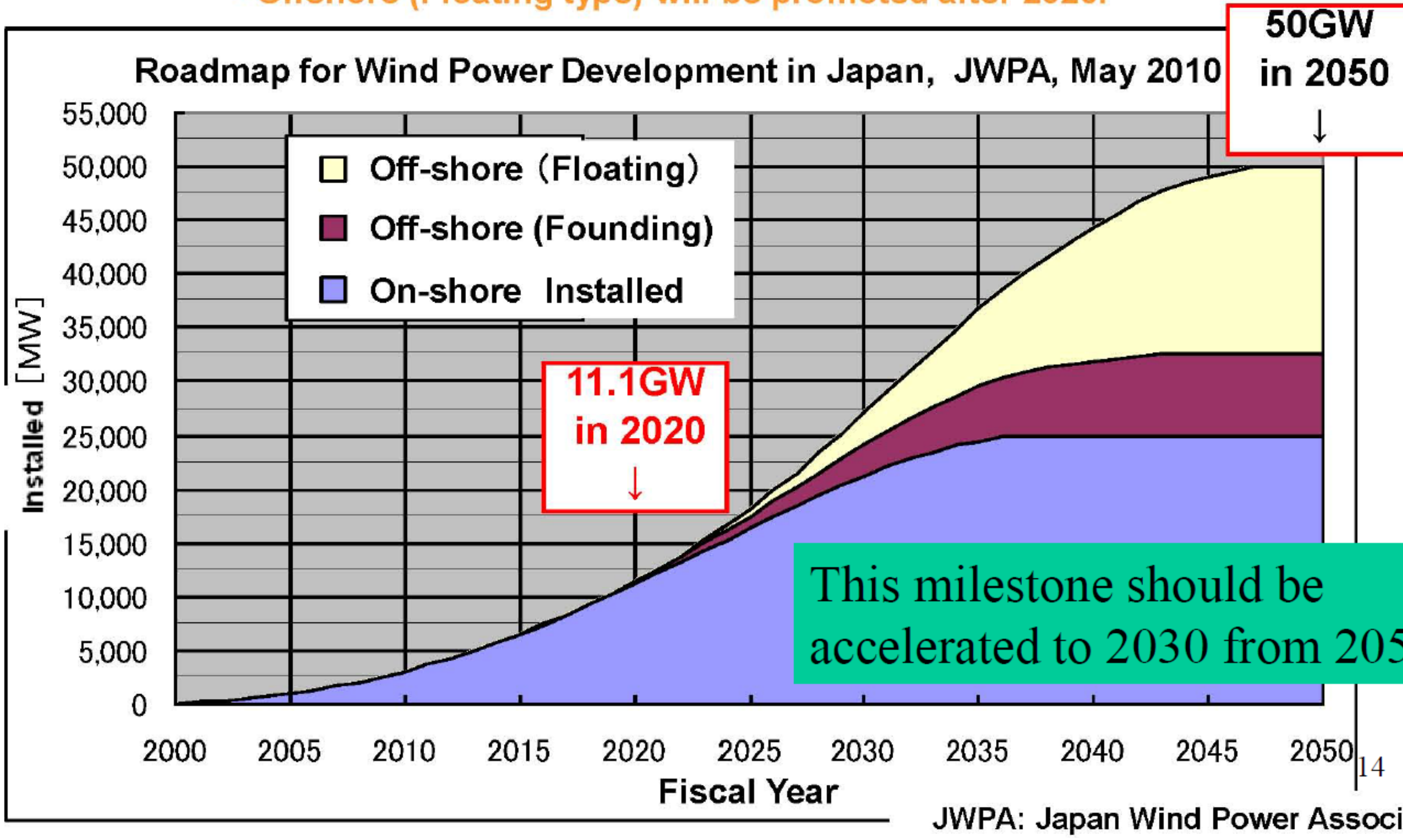
Ref: Japan Wind Power Association

JWPA's proposal to Japanese Government

- Wind power shall supply 10% electricity demand in Japan by 2050.
- Installed capacity shall be 11.1GW in 2020 and 50GW in 2050.
  50GW = On-shore 25GW + Off-shore 7.5GW + Floating 17.5GW
- Offshore (Founding type) will be promoted after 2015.
- Offshore (Floating type) will be promoted after 2020.



This milestone should be accelerated to 2030 from 2050.

JWPA: Japan Wind Power Association

DTU

(3)Installation Plans of Renewable Energy Resource

	Unit	End of 2005	End of 2020	End of 2030
		Actual Achievement	Plan	Plan
PV	Gℓ	0.35	7.00	13.00
	GW	1.42	28.00	53.21
WT	Gℓ	0.44	2.00	2.69
	GW	1.08	4.91	6.61
Waste Power Generation & Biomass Power Generation	Gℓ	2.52	3.93	4.94
	GW	2.23	3.50	4.40
Biomass Heat Utilization	Gℓ	1.42	3.30	4.23
Others	Gℓ	6.87	7.63	7.16
Total	Gℓ	11.60	23.86	32.02

Note: Peak Demand in Japan (2009 base) 180GW
Maximum Capacity in Japan (2009 base) 240GW

New Windlens Turbine (3kW rated at 10m/s) Project supported by Mnis. Environ.(2010-2012)

Structure

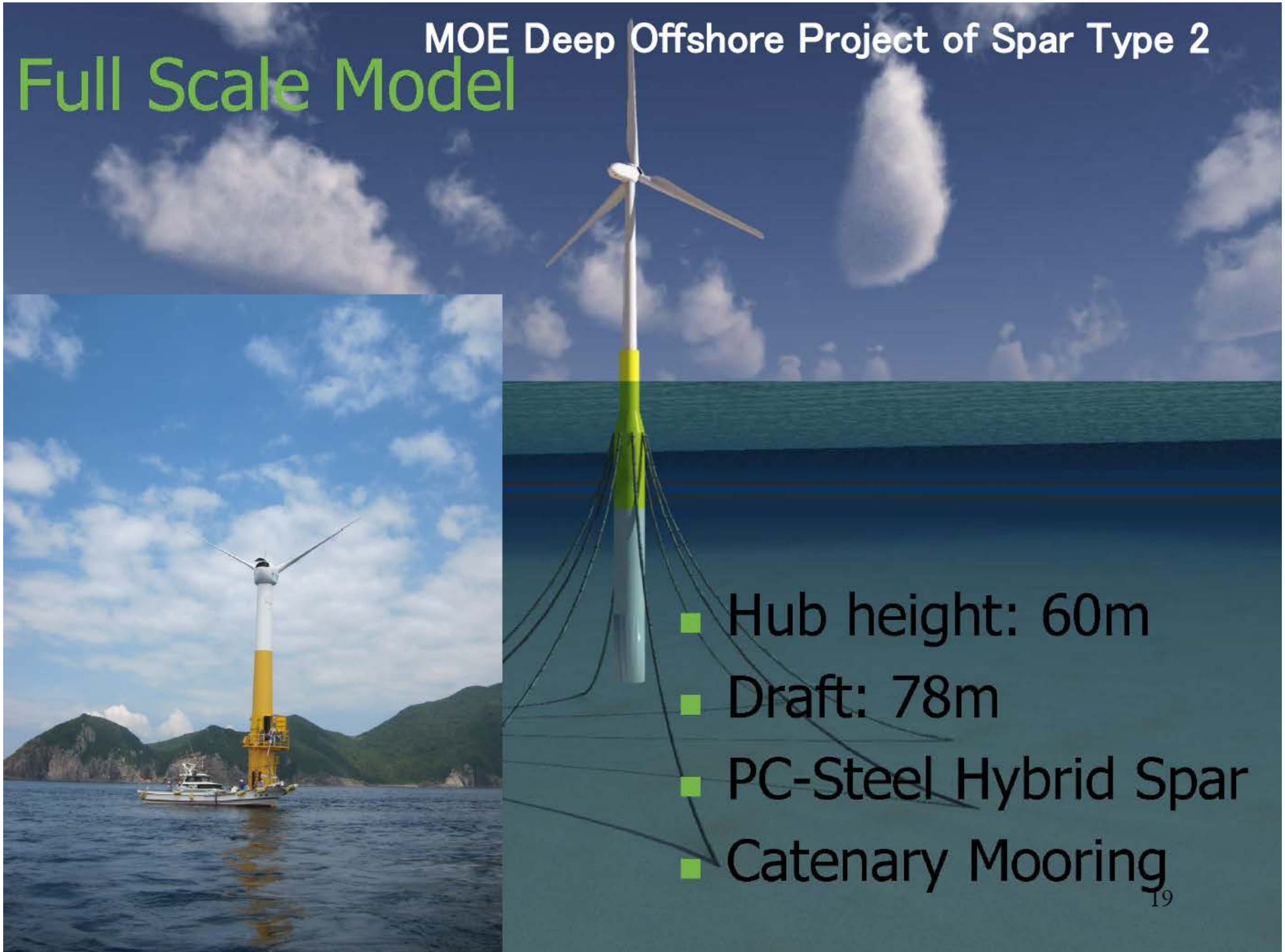
- **Less weight & more strength**
- **long durability**

For strong wind

- **Stall control**
- **Tilt-up pole**

Certification FIT

Creating jobs for small & medium-sized manufactures in Japan


MOE Deep Offshore Project of Spar Type 2
Full Scale Model
Hub height: 60m
Draft: 78m
PC-Steel Hybrid Spar
Catenary Mooring
19

PV Technology Demonstration Project

◆**Number of PV-equipped houses: 553**
Total PV capacity: 2,129 kW
Average capacity per house: 3.85 kW

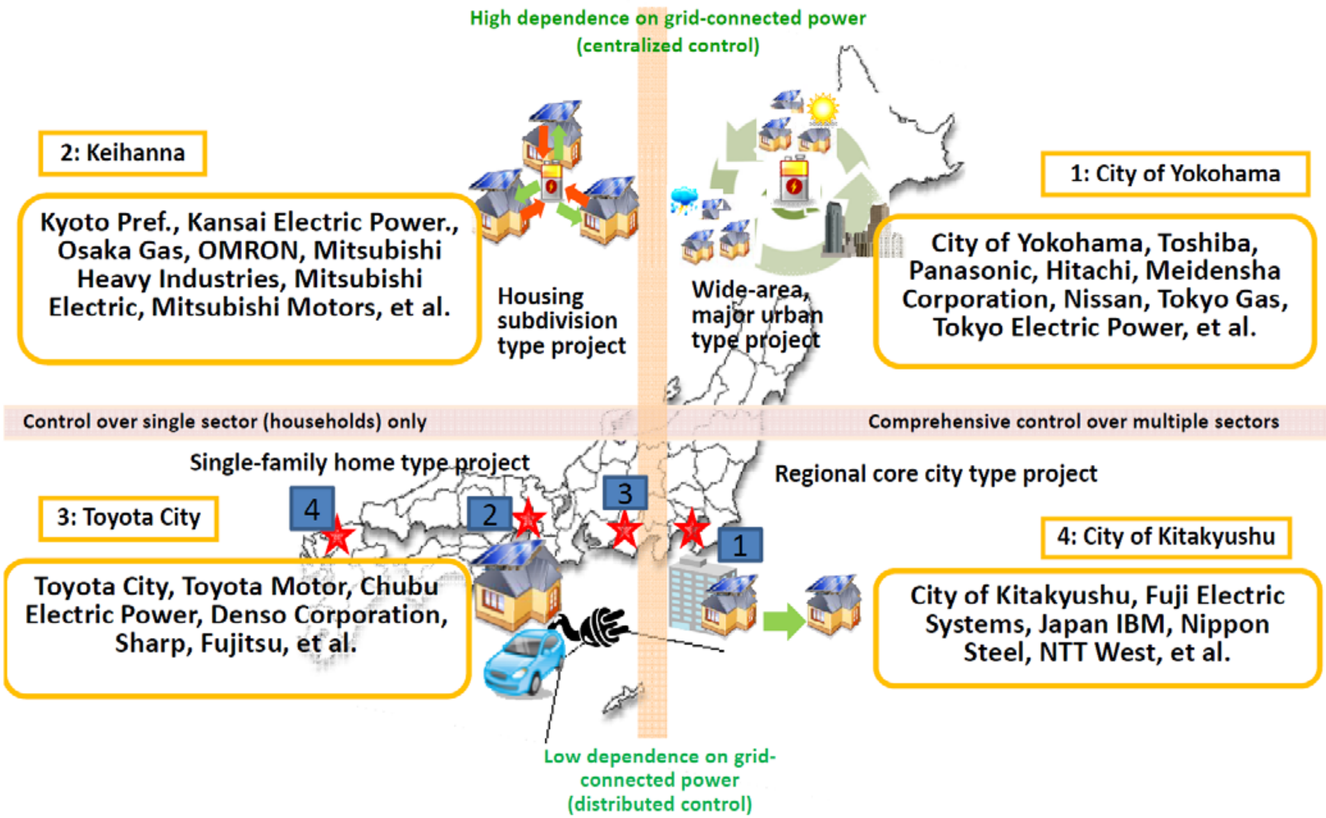
Demonstration Project on Grid-interconnection of Clustered PV Power Generation Systems (FY2002-FY2007)

Wakkanai Demonstration site

◆**Wakkanai site**
5 MW: Most PV cells are crystalline.
NaS battery: 1500 kW-7.2hrs

Verification of Grid Stabilization with Large-scale PV Power Generation Systems (FY2006-FY2010)

(5) Smart Community Demonstration Project



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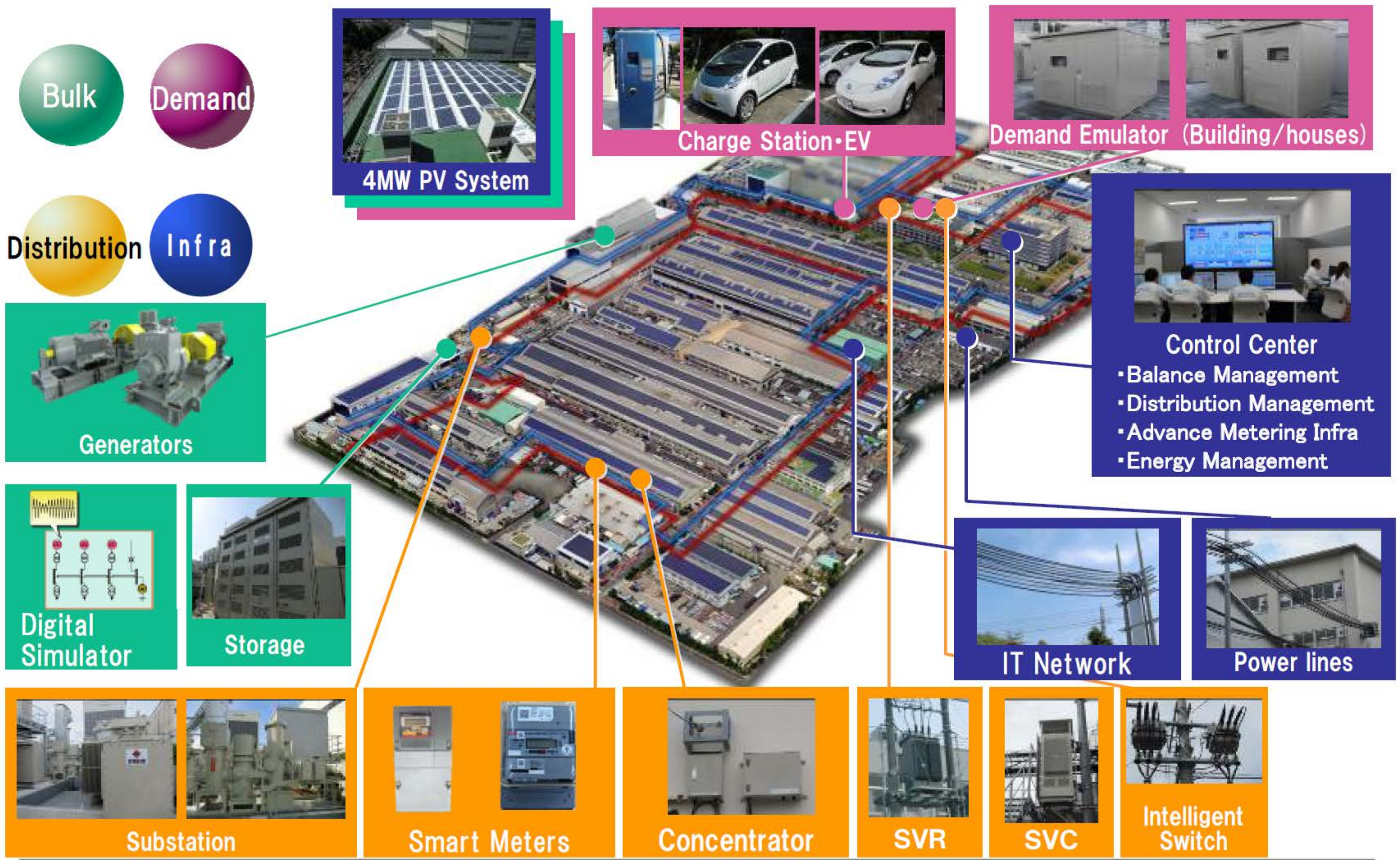
FUKUOKA Island City Project
Renewable Energy
新青果市場
Mega PV System
Floating Type WT Gen.
Biomass Generation
Home Energy Management System
Smart House
Zero CO2 Emission Town
Uninterruptible Power Supply
太陽光発電
蓄電池
照葉小中学校
アイランドシティ イメージパー
New Transportation System
V2H & V2G System
Car Sharing by IT
電動 Bus
Community EMS
地域内エネルギーネットワーク
（地域内情報通信ネットワーク）

MITSUBISHI ELECTRIC
Changes for the Better

Mitsubishi Smart Grid Testbed (Amagasaki Works)

for a greener tomorrow



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Role of organizations

METI: Minister of Economy, Trade and Industry

NEPC: New Energy Promotion Council

Domestic Smart Community projects

NEDO: New Energy and Industrial Technology Development Organization

International Smart grid and Community projects

独立行政法人 新エネルギー・産業技術総合開発機構

History of NEDO demonstration projects

Before year 2000

Grid connecting technology development for one renewable energy

Year 2000 – Year 2010

Multiple or large scale renewable grid connecting demonstration

After Year 2010

Smart community demonstration considering social needs

独立行政法人 新エネルギー・産業技術総合開発機構

Markedsundersøgelse af japansk børsnoteret virksomhed med 30.000 medarbejdere:

Hypothesis: Selection of target markets [redacted]

Confidential

Prioritize the market study of EU
Parallel the study of Open-ADR to survey the standardization processes

Country	Issues to solve	Hypothesis
Denmark	・Deploy renewable energy 30% by 2025 (A Visionary Danish Energy Policy 2025) ・Aggressive deployment of wind power with 30% of power consumption	Stabilization of power grid by the power management from the demand side: Demand Response + [redacted]
Sweden	・Escape from fossil power generation to the deployment of renewable energy especially Wind (Elcertifikat) ・Increasing power consumption because of electric heaters ⇒Necessity for the energy efficiency	Decrease peak power by the power management from the demand side: Demand Response + [redacted]
Finland	・Top ranking of power consumption among EU countries by the cold weather and the pulp industry ⇒ Highly dependent on power imports ・Insufficient power resources ⇒Introduction of renewable energy 38% by 2020 and the policies of power savings	Decrease peak power by the power management from the demand side: Demand Response + [redacted]
US	Deployment of Demand Response by regional power companies Standardization of Open-ADR led by NIST	Necessity to cooperate with Open-ADR for the standardization of [redacted]

Thank you for the attention!

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